# Chapter 6

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"We learn by pushing ourselves and finding what really lies at the outer reaches of our abilities."

- Josh Waitzkin

# Too Much Coffee?

In one experiment, 14 researchers trained a random sample of male US liberal arts college students to tap their fingers at a rapid rate. The sample was then divided at random into two groups of 10 students each. Each student drank the equivalent of about two cups of coffee, which included about 200 mg of caffeine for the students in one group but was decaffeinated coffee for the second group. After a 2-hour period, each student was tested to measure finger tapping rate (taps per minute). The students did not know whether or not their drinks included caffeine and the person measuring the tap rates was also unaware of the groups. The goal of the experiment was to determine whether caffeine produces an increase in the average tap rate.

**(1)** What is the response variable for this problem?

A Whether or not caffeine was included

B Whether or not there was a high tap rate

C Number of cups of coffee

D Number of students in each group

E None of the above

# Explanatory Variable

**(2)** What is the explanatory variable?

A Type of coffee given

B Number of hours after drinking coffee

C Whether or not caffeine impacts tap rate

D Increases in the average tap rate

E None of the above.

**(3)** What is the population in this problem?

A All students at colleges in the US

B Students at liberal arts colleges in the US

C All Americans

D All coffee drinkers

E None of the above

**(4)** Why was random sampling used to select the observational units?

A Random sampling ensures that causation can be implied.

B Random sampling lets us make inferences to all male US liberal arts college students.

C Random sampling lets us make strong conclusions about only the samples selected.

D Random sampling ensures that all members of the population are equally likely to be selected in the samples.

E Two of the above are correct.

**(5)** What type of study was this?

A Experiment: the sample was randomly selected.

B Observational study: the researchers only observed the tap rate.

C Experiment: the observational units were randomly assigned to a tap rate.

D Observational study: the explanatory variable was assigned to the participants at random.

E None of the above.

Denote $\mu_c$ as the mean tap rate for the population of male students with caffeine and $\mu_n$ as the similar rate without caffeine.

**(6)** Identify the correct alternative hypothesis.

A $\mu_c - \mu_n = 0$

B $\mu_n < \mu_c$

C The mean tap rates are the same with or without caffeine.

D $\mu_c - \mu_n \neq 0$

E None of the above

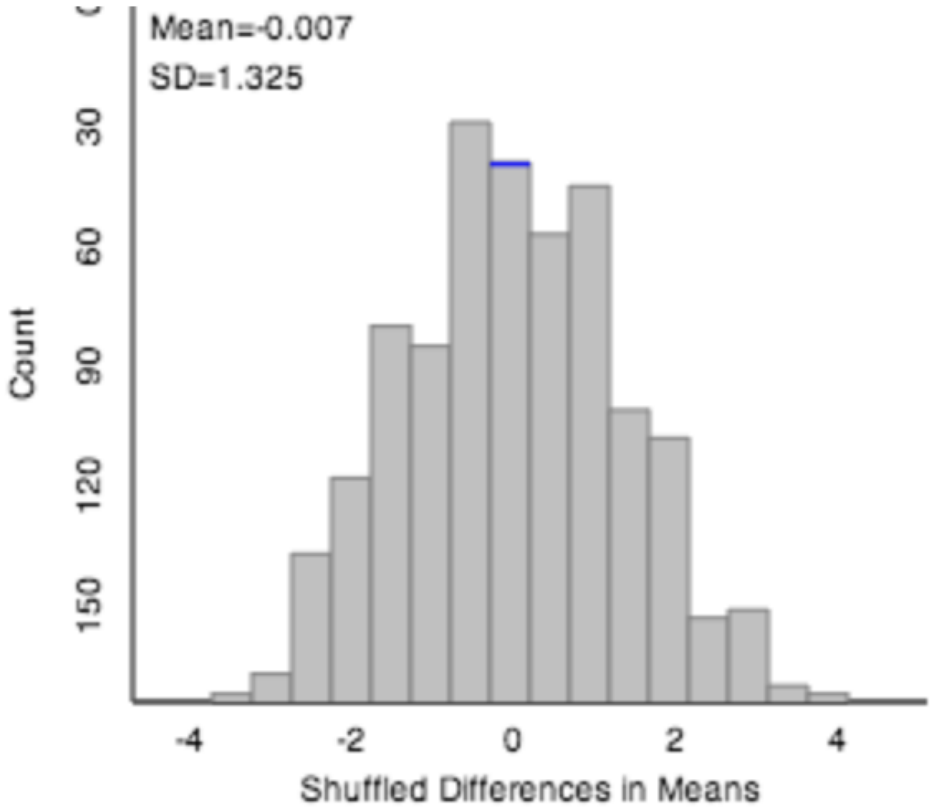
**(7)** For this problem, we have an observed difference in sample means of $\bar{x}_c - \bar{x}_n$ of 3.5. Based on the picture, is there evidence that caffeine increases tap rate?

A Yes, the $p$-value is large.

B No, the $p$-value is small.

C No, the $p$-value is large.

D Yes, the $p$-value is small.



**(8)** Suppose that the goal of the experiment was to determine whether caffeine produces an EFFECT in the average tap rate. What could we say about the corresponding confidence interval based on the size of the $p$-value on the last slide?

A It will be entirely positive.

B It will include 0.

C It will include 3.5.

D Two of the above are true.

E None of the above.

**(9)** If your sample does not meet the validity conditions, what are your options?

A You should not use simulation-based methods and instead use theory-based methods.

B You can use either simulation-based or theory-based methods since validity conditions have to do with how the sample was collected.

C You will need to collect a different sample and start the entire process over again.

D Two of the above are true.

E None of the above.

**(10)** What does a $p$-value correspond to in this chapter?

A The proportion of sample averages as extreme or more extreme than what we observed in our sample out of the total number of simulated sample averages.

B The probability of obtaining a sample proportion of successes as extreme or more extreme than what we observed, assuming the null hypothesis is true.

C The number of simulated differences in sample averages as extreme or more extreme than what we observed in our original sample divided by the total number of simulated differences.

D Two of the above are true.

E None of the above.

# Key Terms and Ideas to Understand in Chapter 6

- Five-number summary
- Boxplots
- Standard deviation of the sample
- $p$-value
- Observational/experimental unit
- Explanatory/response variables
- Generalization
- Cause-and-effect
- 2SD Method for a CI for $\mu_1 - \mu_2$